2.7 Verifying High-Resolution Satellite Precipitation Estimates on Sub-daily Scales: Results for Southern China

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1. INTRODUCTION

In recent years, several new techniques have been developed to generate precipitation estimates on high time-space resolution over the globe by combining information from microwave (MW) and infrared (IR) satellite observations (Hsu et al. 1997, Turk et al. 2004, Huffman et al. 2004, and Joyce et al. 2004). While these high-resolution precipitation estimates have been utilized widely in a variety of meteorological and hydrological applications, quantitative examinations of these satellite products are needed to provide critical information on their performance upon which further improvements may be made and strategy to combine them with other observations (such as gauge-based analyses) may be designed. Recently, several research has been published to examine the performance of the satellite precipitation products in reproducing spatial and temporal variation patterns on a time scale of daily or longer (e.g. Ebert et al. 2006, Xie et al. 2006).

Most of the high-resolution satellite precipitation products are generated on a time scale of 3-hourly or better. Assessments of their performance on sub-daily time scales, however, are not an easy task due largely to the lack of a gauge-based analysis of appropriate time-space resolution.

Recently, we have created an analysis of hourly precipitation on a 0.125^{o}lat/lon grid over Guang-Dong Province in Southern China and applied it to verify the performance of several selected high-resolution satellite precipitation estimates. This paper provides a general description of the gauge-based hourly precipitation analysis and the verification results for summer 2005.

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2. THE GAUGE-BASED HOURLY PRECIPITATION ANALYSIS

An analysis of hourly precipitation is constructed on a 0.125^{o}lat/lon grid over Guang-Dong province in southern China for 2005 by interpolating gauge observations at over 400 stations (fig.1). The overall interpolation strategy is a modification of that of Xie et al. (2006) who developed a three-step algorithm to produce precipitation analyses over East Asia.

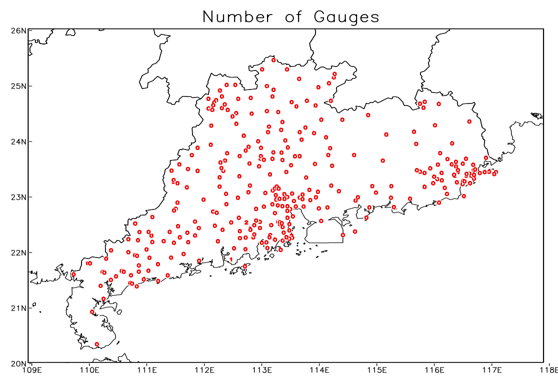

Fig. 1: Network of hourly gauges over Guan-Dong Province in Southern China. The province of ~150,000 Km^2 is covered by a total of ~400 gauges.

First, a gridded analysis of daily precipitation climatology is created for each of the 365 calendar days using GTS daily precipitation reports for a 20-year period from 1978 to 1997. For this purpose, daily precipitation climatology are defined for all GTS stations within the domain with 90% or higher reporting rates by accumulating the first 6 harmonic components of the 365-day time series of the 20-year mean values. Analyzed fields of daily precipitation climatology are then defined by interpolating the station climatology through Shepard (1968) and by adjusting it against the PRISM (Daily et al. 1994) monthly climatology over the region. The purpose of this adjustment is to better represent the orographic effects in precipitation that are not accounted for in the interpolation of the daily station climatology through Shepard (1968) which is primarily a inverse-distance technique.

The second step of the algorithm involves the definition of an analyzed field of ratio of hourly precipitation to daily climatology. This is done by interpolating the corresponding station values, defined as the ratio of hourly observation at a station to the daily climatology at the grid box at the gauge location, using the Optimal Interpolation (OI) algorithm of Gandin (1965).

In the final step, the analysis of total daily precipitation is calculated by multiplying the analyzed daily climatology with the ratio.

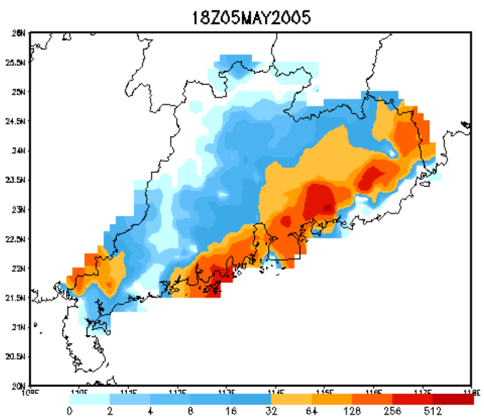

Fig.2 Distribution of gauge-based hourly precipitation (0.1mm/day) for 18Z, May 5, 2005.

Fig.2 shows an example of the gauge-based analysis of hourly precipitation for 18Z, May 5 of 2005. A band of heavy rainfall, passing over the target area with a maximum of more than 40 mm/day, is well depicted by our gauge-based analysis. In this study, we have created the gauge-based hourly precipitation for a 6-month period from March to August of 2005.

3. EXAMINATIONS OF THE SATELLITE PRECIPITATION PRODUCTS

The gauge-based analysis of hourly precipitation is regridded into 0.25^{o}lat/lon and 3-hourly resolution and applied to assess the performance of several satellite-based high-resolution precipitation estimates for a 3-month period from April 1 to June 30, 2005. The satellite products examined here include 1) the CPC MORPhing products (CMORPH) of Joyce et al. (2004); 2) simple average of the microwave-based estimates used in creating the CMORPH (MWCOMB); 3) the gauge-adjusted MW-IR merged analysis of TRMM 3B42 (Huffman et al. 2004); and 4) its real-time version TRMM 3B42RT which is a MW-IR merged product without gauge adjustments. Details of the satellite products may be found from their respective references. Comparison of CMORPH and MWCOMB provides us with an estimation of how much the precipitation products are improved by including information from the IR observations.

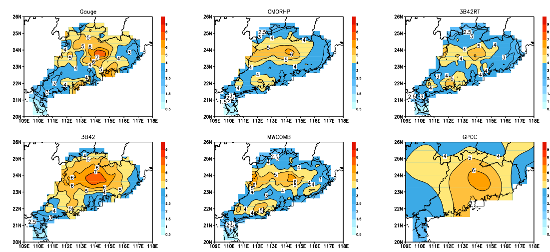

Fig.3 *Distribution of precipitation for April – June, 2005, from a) our gauge-based analysis (left top), b) CMORPH (middle top), c) TRMM 3B42RT (right top), d) TRMM 3B42 (left bottom), e) MWCOMB (middle bottom), and f) the GPCC gauge-based analysis of monthly precipitation.*

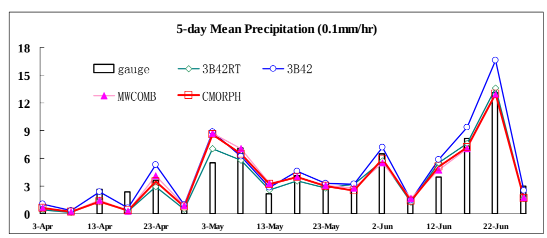

Fig.4 Time series of pentad mean precipitation over the entire target domain.

Spatial distribution (fig.3) and temporal variation patterns (fig.4) of warm season precipitation over the target domain are well depicted by all of the satellite products examined here. Satellite-based products, however, tend to miss small-scale features and contain bias compared to our gauge-based analysis. Although previous studies (Berth et al. 2006, Xie et al. 2006) showed minor biases in the TRMM 3B42 defined by adjusting satellite estimates to the gauge-based monthly precipitation analysis of GPCC, our comparison here revealed bias in the TRMM 3B42 with magnitude comparable to that in other satellite products. A brief examination of the mean precipitation distributions suggested that this is caused by the bias in the GPCC gauge analysis which is derived from observations at ~20 gauges over the region, compared to those from ~400 gauges used in our gauge analysis.

Figure 5 presents the spatial distribution of serial correlation between our gauge-based analysis and the selected satellite products on 0.25°lat/lon and 3-hourly resolution. Reasonable correlation is observed over most of the region and for all of the satellite products examined here. Overall, satellite estimates perform better over coastal regions than over inland mountainous areas. Among the four satellite products, CMORPH shows the best correlation over most of the region.

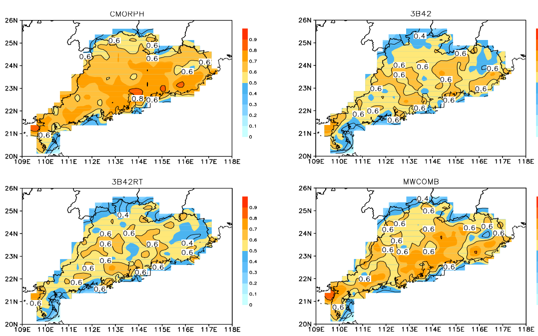

Fig. 5 Serial correlation between the gauge analysis and satellite estimates of 3-hourly precipitation on a 0.25°lat/lon grid. Results for CMORPH, TRMM 3B42, TRMM 3B42RT, and MWCOMB are plotted in the left-top, right-top, left-bottom and right-bottom panels, respectively.

Pattern correlation for 3-hourly precipitation (fig.6) is relatively low when mean precipitation is small during the onset process of monsoon and reaches to stable levels from the mid of April. The CMORPH exhibits best correlation with gauge-based analysis throughout the comparison period.

Performance of the satellite precipitation products improves with the accumulating time scales (table 1). Correlation between the gauge analysis and CMORPH increases from 0.658 for 3-hourly precipitation to 0.753 for daily accumulations.

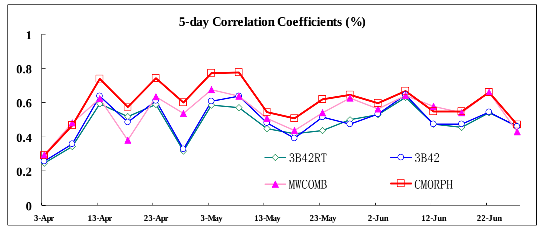

Fig.6: Time series of pattern correlation between our gauge-based analysis and the selected satellite precipitation products on 0.25°lat/lon grid boxes and in 3-hourly time-resolution. Only data over grid boxes with al least one gauge are included in calculating the statistics.

Differences in correlation for the MW-IR merged CMORPH and the all MW-based MWCOMB, meanwhile, reduces from 0.068 for 3-hourly to 0.055, implying that including IR information contributes more in generating precipitation estimates of high temporal resolution. Consistent with shown in fig.2, all of the four satellite products present bias compared to our gauge-based analysis.

Table 1: Results of Comparison between the Gauge-Based Analysis and the Selected Satellite Products on a 0.25°lat/lon Grid over Guang-Dong Province, China, for April – June, 2005

	3hr		**6hr**	**12hr**	**24hr**
	Bias	Corr	Corr	Corr	Corr
CMORPH	-0.289	0.658	0.696	0.726	0.753
MWCOMB	-0.318	0.590	0.630	0.668	0.698
3B42	0.520	0.549	0.606	0.658	0.711
3B42RT	-0.433	0.538	0.593	0.628	0.684

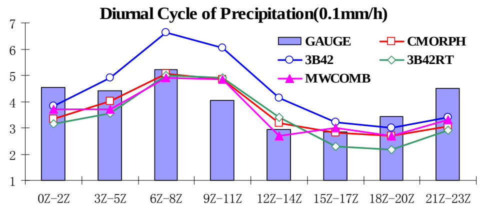

Fig.7: Diurnal cycle of precipitation derived from our gauge analysis and the four satellite products averaged over the target domain for a 3-month period from April – June, 2005.

Mean diurnal cycle of precipitation over the region is well captured by the four satellite products examined here. Both the afternoon and the early morning peaks in precipitation are reproduced reasonably well in the satellite products, though with overall bias throughout the diurnal cycle. The diurnal cycle of precipitation derived from the satellite products, however, does not drop as much as that in the gauge observations after the afternoon peak and its second peak in early morning is not as strong as in the observations.

4. SUMMARY

An analysis of hourly precipitation is constructed on a 0.125^{o}lat/lon grid over Guang-Dong Province in Southern China and applied to examine the performance of four high-resolution satellite precipitation products, including CMORPH, the simple combination of all MW-based estimates used in CMORPH (MWCOMB), TRMM 3B42 and TRMM 3B42RT for April to June, 2005. Our preliminary results showed the following:

1) All of the four satellite products are capable of capturing the overall spatial distribution and temporal variations of precipitation reasonably well;

2) Performance of the satellite presents varies for different regions and different precipitation regimes. In particular; and

3) Diurnal cycle of precipitation is captured quite well but the early morning peak is under-estimated by all products;

Further work is underway to perform case studies and to extend the statistical analysis. Detailed results will be reported at the workshop.

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